Space Weather Technical Forecast

Issued on Tuesday, 12 December 2023 at 13:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of isolated M-flares, risk decreasing by Day 4 (15 Dec).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low with the peak flare a C9.1 at 12/0338 UTC from AR3514.

There are currently seven sunspot regions on the visible disc, following the departure of AR3507, AR3508 and AR3511 across the west limb. The most active region has been AR3514 (Dai/Beta), which continues to develop, and briefly saw the formation of a marginal delta spot on its leading portion. AR3513 (Eai/Beta-Gamma) is the largest region on the disc, but has shown decay. A new region has developed in an area of plage to the rear of ex-AR3511 and a further new region is emerging from the northeast limb, although the viewing angle is restricted and confidence in its classification is low.

No Earth-directed (CMEs) were observed in available imagery. However, dimming events have been observed in the vicinity of AR3514 associated with Common-class flares and are yet to be analysed. A filament lift-off from the southwest disc around 12/0900 UTC may have produced a CME but is not yet visible on available imagery.

Solar Wind / Geomagnetic Activity: Solar winds as observed by ACE and DSCOVR at L1 were at slow-ambient levels. Wind speeds as measured by ACE were initially around 360 km/s, but declined gradually to around 310 km/s around 11/1830 UTC. Winds inclined slightly from 12/0550 UTC, returning to 340km/s. Density has remained below average throughout. The Total Interplanetary Magnetic Field (Bt) was mostly weak, peaking briefly at 8nT around 12/0830 UTC, while the north-south component (Bz) varied weakly. Phi angle was predominantly negative (towards the Sun), but has been positive (away from the Sun) since 12/0430 UTC. The wind parameters suggest that there may be some weak enhancement from a HSS from CH77/+, although the main stream is projected to pass below Earth's orbit. Geomagnetic activity was Quiet (Kp 0-1).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux was predominantly moderate, but was at high levels 11/1400-1745 UTC, peaking at 1340pfu at 11/1440UTC. The 24-hour fluence was below the Active threshold (1e8 integrated pfu). The observation at 12/0000UTC was 4.82e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally Low solar activity is expected to continue, with a chance of isolated M-flares. These are most likely to emanate from AR3513 or AR3514.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs currently expected in the forecast period. However, there are a number of recent features yet to be analysed as imagery becomes available.

Solar winds are most likely to continue at background levels Days 1-2 (12-13 Dec) before the

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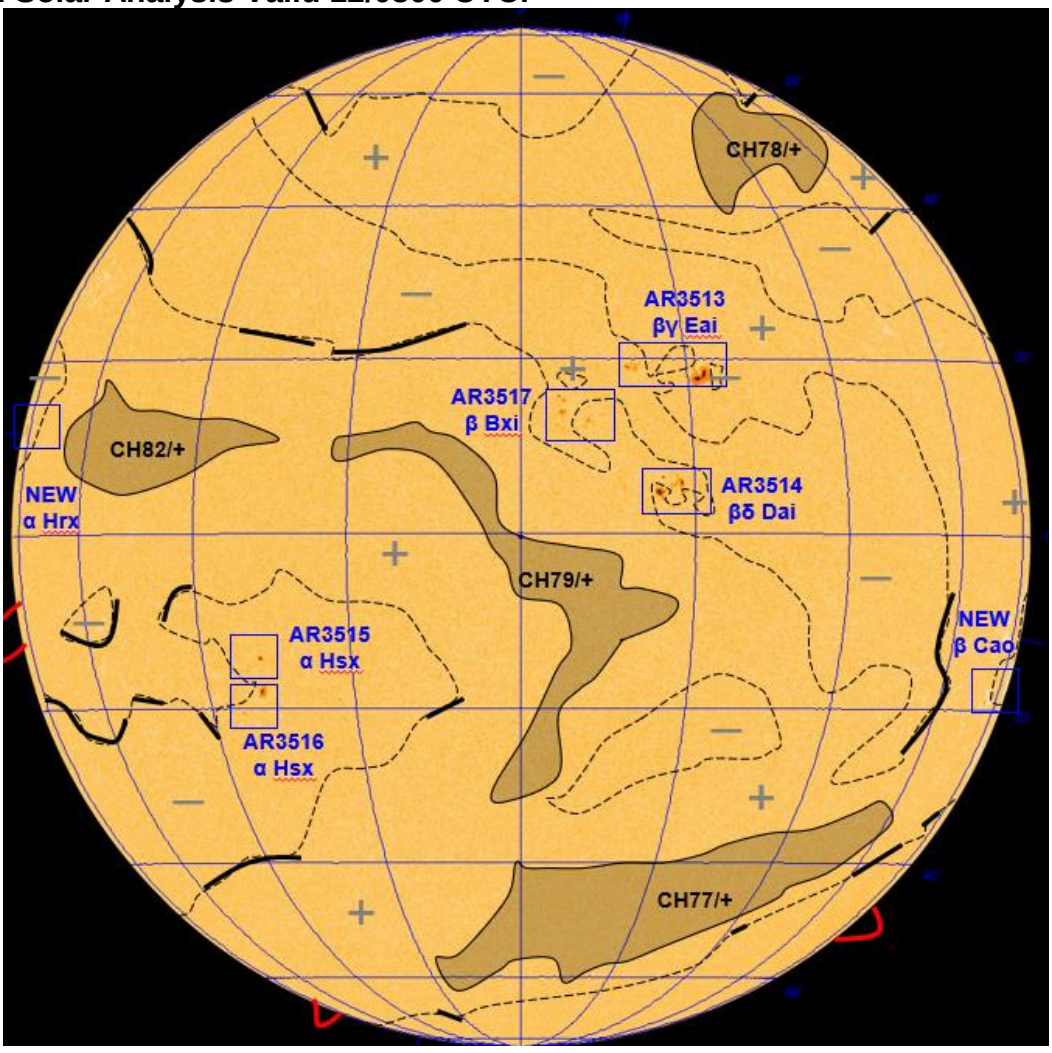
onset of a HSS during Day 3 (14 Dec). However, confidence is low in timing and peak wind speeds due to the non-persistent nature of this feature, but slightly elevated winds are expected, possibly reaching elevated levels.

The current Quiet (Kp 0-2) geomagnetic activity is likely to continue until the onset of the HSS from CH79/+, which is anticipated to be on Day 3 (14 Dec). Unsettled to Active conditions are then likely, with a very slight chance of an isolated G1/Minor Geomagnetic Storm interval (Kp 5), but this is considered a low probability at this stage.

Energetic Particles / Solar Radiation: GOES16 high energy proton is expected to persist at background levels, with only a very slight chance of rising towards the S1/Minor Radiation Storm level given any significant flares from ex-AR3511 on Day 1 (12 Dec) and other contributions from AR3513 or AR3514. High energy electron flux is expected to be moderate at first, perhaps with diurnal peaks close to, or reaching, the high threshold. A drop out is possible with HSS enhancement on Day 3 (14 Dec). The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold, but perhaps rising closer to Active through Days 3-4 (14-15 Dec).

Figure 1. Solar Analysis Valid 12/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs currently expected in the forecast period. However, a dimming event was observed around 12/0338 UTC in the vicinity of AR3514 associated with a C9 flare. A CME observed emerging to the west on coronagraph imagery may be attributed to this, but is yet to be analysed.

Solar winds are most likely to continue at background levels Days 1-2 (12-13 Dec), before the anticipated arrival of a HSS from CH79/+ on Day 3 (14 Dec). Confidence is low in the timing and peak wind speeds due to the non-persistent nature of this coronal hole, but slightly elevated winds are expected, possibly reaching elevated levels Days 3-4 (14-15 Dec).

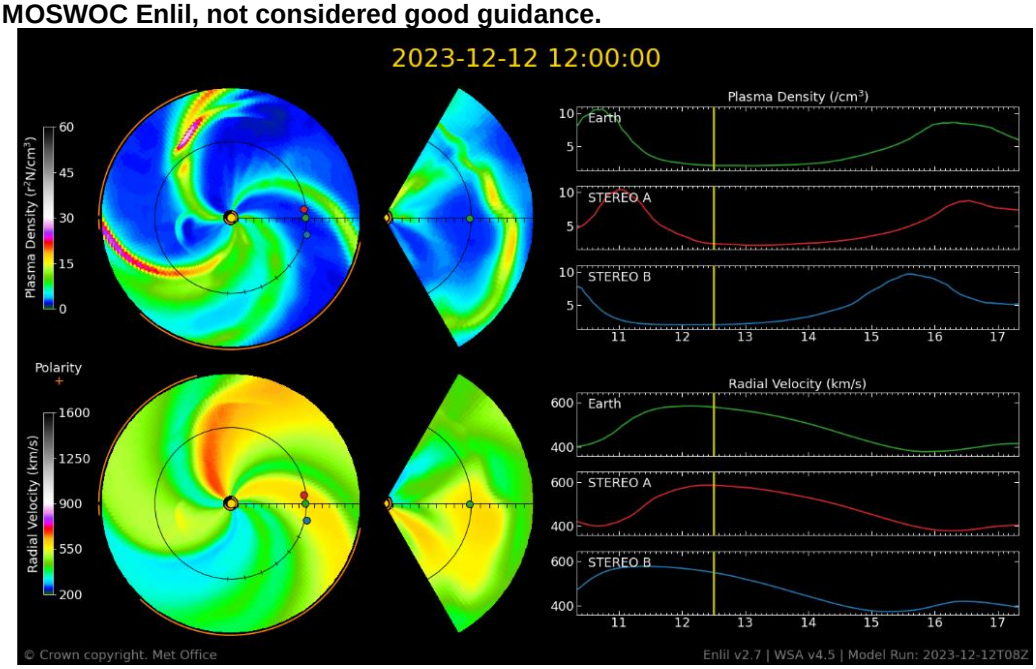
The current Quiet (Kp 0-2) geomagnetic activity is likely to continue until the onset of the HSS from CH79/+, which is anticipated to be on Day 3 (14 Dec). There is a slight chance that the onset of the HSS may produce an isolated G1/Minor Geomagnetic Storm interval (Kp 5), but this is considered a low probability at this stage, with Unsettled to Active conditions more likely.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	5	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

No Earth-directed CME's currently expected.

Figure 2: MOSWOC Enlil, not considered good guidance.



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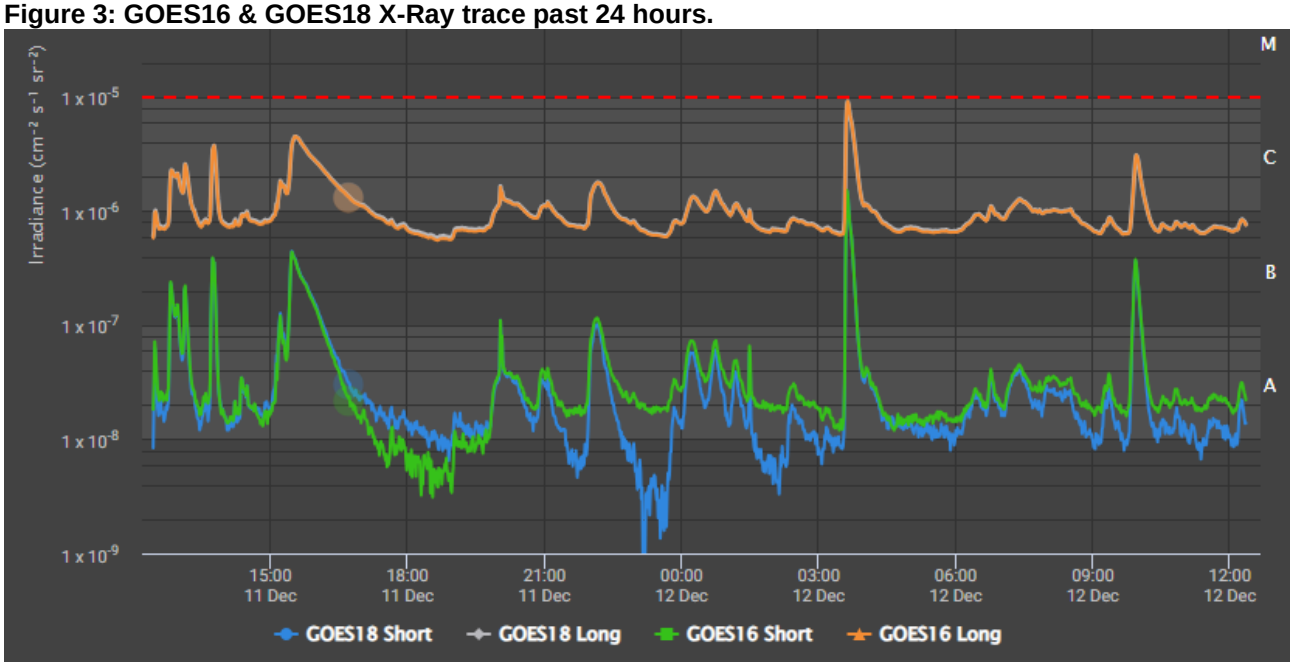
Radio Blackouts - X-Ray Flares:
There are currently five numbered and two unnumbered sunspot regions on the visible disc. AR3511, previously the most active region on the disc, has transited beyond the western limb. AR3513 (Eai/Beta-Gamma) remains the largest region on the disc but continues to show decay in its intermediate and trailing spots. AR3514 (Dai/Beta) continues to develop and briefly saw the formation of a marginal delta spot in its lead portion, which has since separated. The region exhibits latitudinal bipolarity, suggesting magnetic complexity and instability. The remaining numbered regions are currently relatively small and simple and are either stable or showing slight signs of decay.

A new region has developed in an area of plage to the rear of ex-AR3511 which has now departed the disc. A further new region is emerging from the northeast limb, although the viewing angle is restricted and confidence in its classification is low.

Seismic analysis of the far-side would suggest that new regions may rotate, or continue to rotate, onto the disc in the coming days, supported by areas of brightness visible beyond the east limb on SDO/AIA-0094.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	35	30	30	20
Very Active	R3 to R5 X Class	No	5	1	1	1

Figure 3: GOES16 & GOES18 X-Ray trace past 24 hours.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background levels. There is a slight chance of this increasing should there be any significant flares, especially from ex-AR3511 which has now passed beyond the southwest limb. The other regions of interest are AR3513 and AR3514 which are now transiting across the western hemisphere. The risk reduces somewhat by Day 2 (13 Dec) as ex-AR3511 continues to rotate away from beyond the west limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	10	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):
High energy electron flux, as observed by GOES-16, has been mainly moderate over the last few days, with diurnal peaks into the high threshold. This pattern is likely to continue through Days 1-2 (12-13 Dec), but with a gradual declining trend in flux levels. A more appreciable suppression is anticipated at some point from Day 3 (14 Dec) following the anticipated HSS enhancement from CH79/+.

The associated 24 hour fluence is expected to remain below the Active threshold, but may rise closer to the Active threshold by the end of the period, depending on the timing and strength of the next anticipated HSS. The REFM is considered to be giving limited useful guidance at present, with the sharp decline on Day 3 (14 Dec) dependent on the strength of connection with the HSS, which is currently uncertain.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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Figure 4: GOES16 Electron Flux trace over past 72-hours

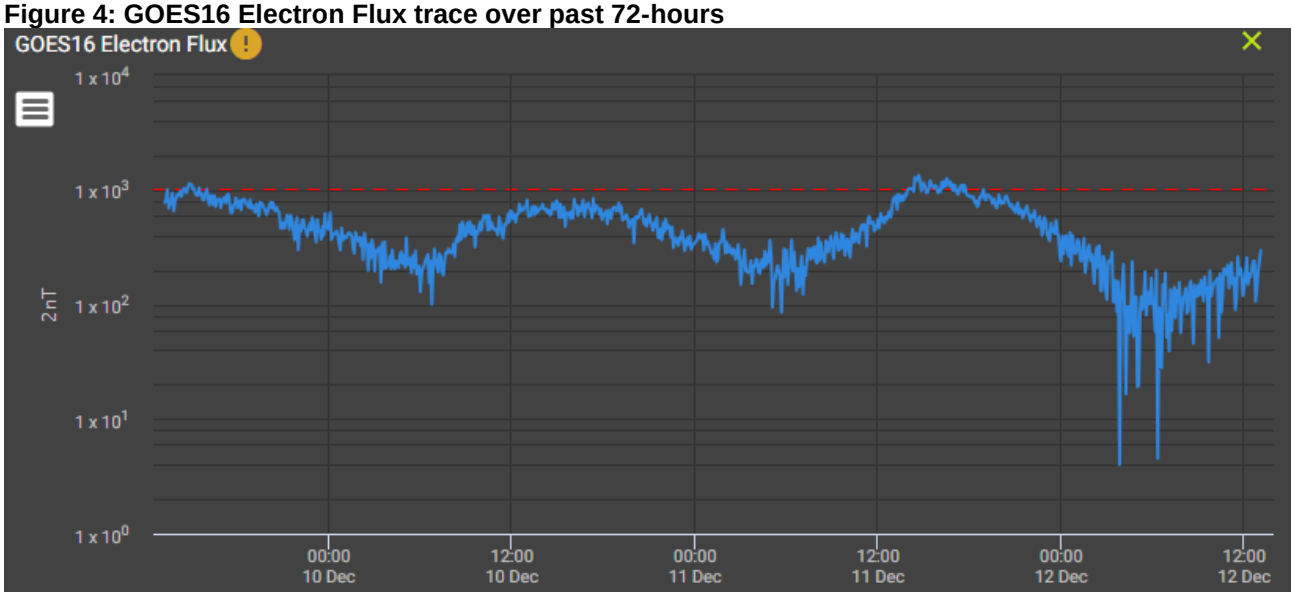
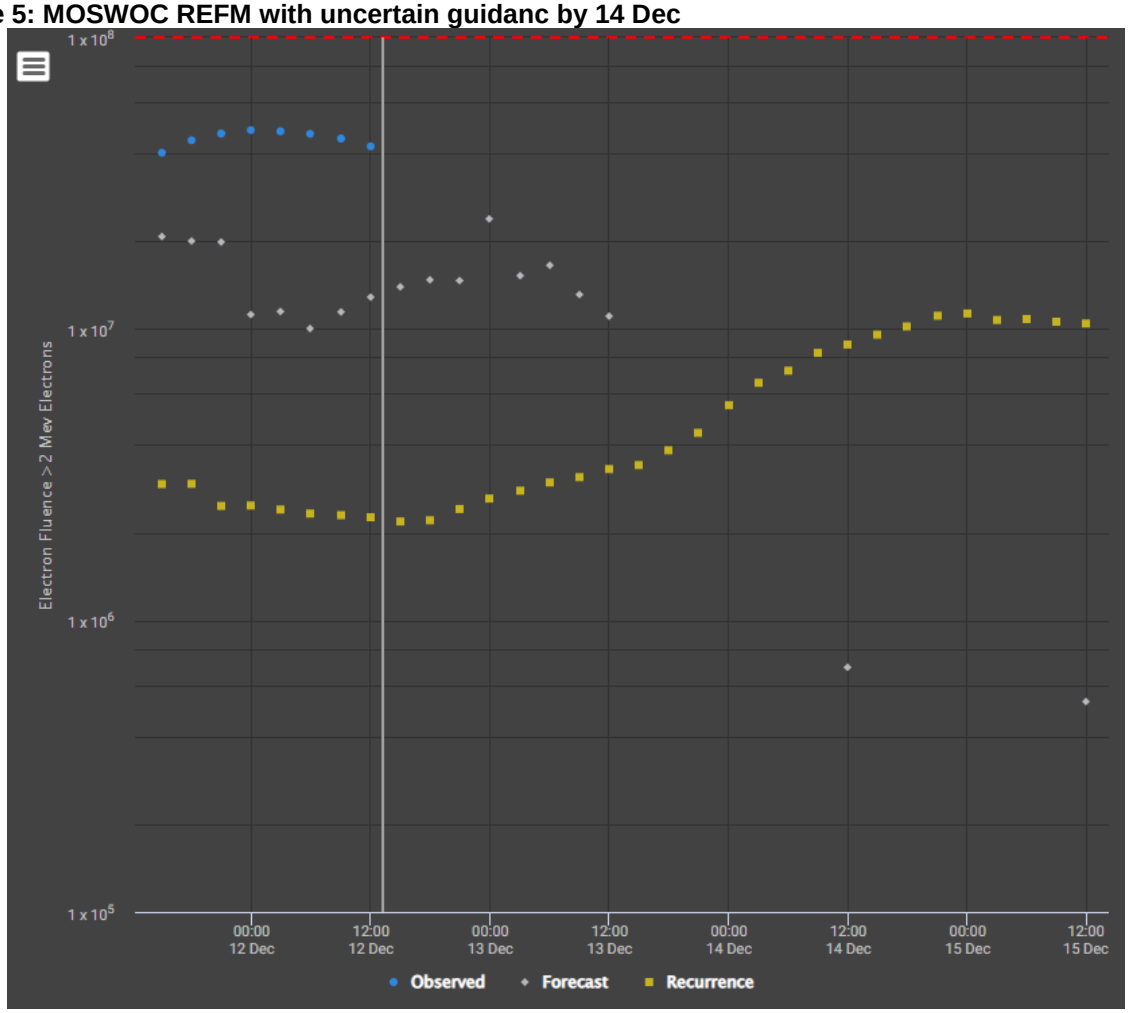


Figure 5: MOSWOC REFM with uncertain guidanc by 14 Dec



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